

Archaeological assessment of coastal and marine development sites: case study from James Price Point, Western Australia

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Abstract

This paper examines the prehistoric marine archaeological potential of relict shorelines off James Price Point, northern Western Australia. In addition to previously registered midden and intertidal fish-trap sites, archaeological excavation at James Price Point has provided evidence of coastal exploitation from at least 5 ky BP. In the adjacent marine environment are well-preserved drowned shoreline sediments, that form at least two series of north - south trending linear features with relief of up to 5 m of more above the surrounding seabed, at elevations of - 15 m and - 8 m respectively, which may date to ~ 9 ky BP and ~ 6 ky BP respectively. The submerged shorelines are associated with four main depositional environments, of which, 'lagoon infill' and 'fossil intertidal flats' have the highest preservation potential and highest archaeological potential. This palaeogeography has significant geoheritage value and systematic investigation of these features is likely to contribute to our understanding of early maritime adaptation and resource use in this region.

KEYWORDS: submerged landscapes, palaeoshorelines, geoheritage, prehistoric marine cultural heritage, James Price Point

INTRODUCTION

The Archaeological Potential of Submerged Areas

With the rapid expansion of marine industrial developments in many regions of the globe, a key challenge is to maximise the opportunities for research to support collaborative monitoring and management of known and potential archaeological sites (Evans *et al.* 2009; Firth, 2015; Flemming 2004; Ward *et al.* 2014a). In Australia there has been little conceptual or practical understanding of the potential impacts of marine development activities (e.g. ports and harbours) upon the largely unknown prehistoric marine resource. Further, the limited statutory framework for marine prehistoric cultural resources means the need for research is even more acute (Kamoot 2014; Staniforth 2007). This major knowledge gap in submerged cultural potential is perhaps most apparent off Western Australia where some of the biggest marine developments are occurring and where we now have some of the oldest records of coastal occupation, extending back some 50,000 years (Veth *et al.* 2014; Veth & O'Connor 2013).

Information from drowned sedimentary deposits can provide valuable information about past environments, past sea levels and associated past cultures (Bailey 2014; Benjamin *et al.* 2011; Flemming 2004). Models designed to examine the potential archaeology of submerged

landscapes include theoretical (Chapman & Lillie 2004; Fischer 2004) and technological approaches (Gaffney *et al.* 2007; 2009; Mahon *et al.* 2011; Webster 2008). Geoarchaeological approaches use the associations between different landforms and different types of archaeological and/or environmental remains (e.g. Howard and Macklin 1999; Rapp and Hill 1998) to estimate of the potential presence of submerged archaeological deposits (Gagliano *et al.* 1982; Ward and Larcombe 2008). This in turn has lead to the development of Indicative Maps of Archaeological Potential or Values (IMAP; Deeben 2009). Such maps are used to indicate those specific areas of the coastal and marine zone interpreted as having relatively low, medium or high potential for the presence of archaeological remains in primary and secondary depositional contexts, i.e. in situ or re-deposited (see also Cohen *et al.* 2014; Ward & Larcombe 2008). Delineating boundaries within IMAPs requires assessment of both the nature of the depositional environments as likely sites of occupation and/or concentrations of archaeological artefacts (Deeben 2009), together with consideration of any post-depositional modification processes (Rowland & Ulm 2012; Ward *et al.* 2015).

Embedded within the established regional geoarchaeological understanding (Ward *et al.*, 2013, 2014b, 2015), this paper applies a geomorphically-based approach to assess the archaeological potential of a small (15 km x 40 km) submerged area off northwest Australia, namely the former gas hub development area of James Price Point, near Broome, on the southern Kimberley

coast. This assessment is necessarily based on an interpretation of (i) the available geological, bathymetric and sedimentary data, including the past and present sedimentary processes and (ii) existing archaeological information, including the known and likely past human use of terrestrial and coastal environments both of which are outlined below. The aim of this assessment is to show the considerable potential for prehistoric marine heritage with the potential to address specific questions of early maritime adaptation (Ward *et al.* 2014b; 2015), and where to focus any future research efforts.

GEOLOGY, BATHYMETRY AND SEDIMENTOLOGY

Regional setting

The continental shelf fringing northwestern Australia

forms an expansive shallow marine environment with a tropical to sub-tropical oceanographic regime, rich carbonate production and low terrestrial sediment supply. In the region of James Price Point, the shelf is broad (100 – 250 km), has relatively low relief and grades gently into the upper slope at depths of 100 – 150 m (Picard *et al.* 2014). Throughout the Pleistocene, the Leveque Shelf and adjacent North West Shelf (Figure 1) have been subject to long periods of sub-aerial exposure at low-stands of sea level. During the Last Glacial Maximum (LGM), sea level in region was 100 – 130 m lower than present, and most of the shelf would have been emergent (Lewis *et al.* 2013; Yokoyama *et al.* 2000). The prolonged low-stand conditions during the LGM appear to have formed a shelf-wide terrace backed by a 30 m high ridge, now located ~125 m below sea level (James *et al.* 2004). Representing the ancient coastline, this ridge is clearly evident on bathymetric surveys of the North West Shelf (WAMSI 2008).

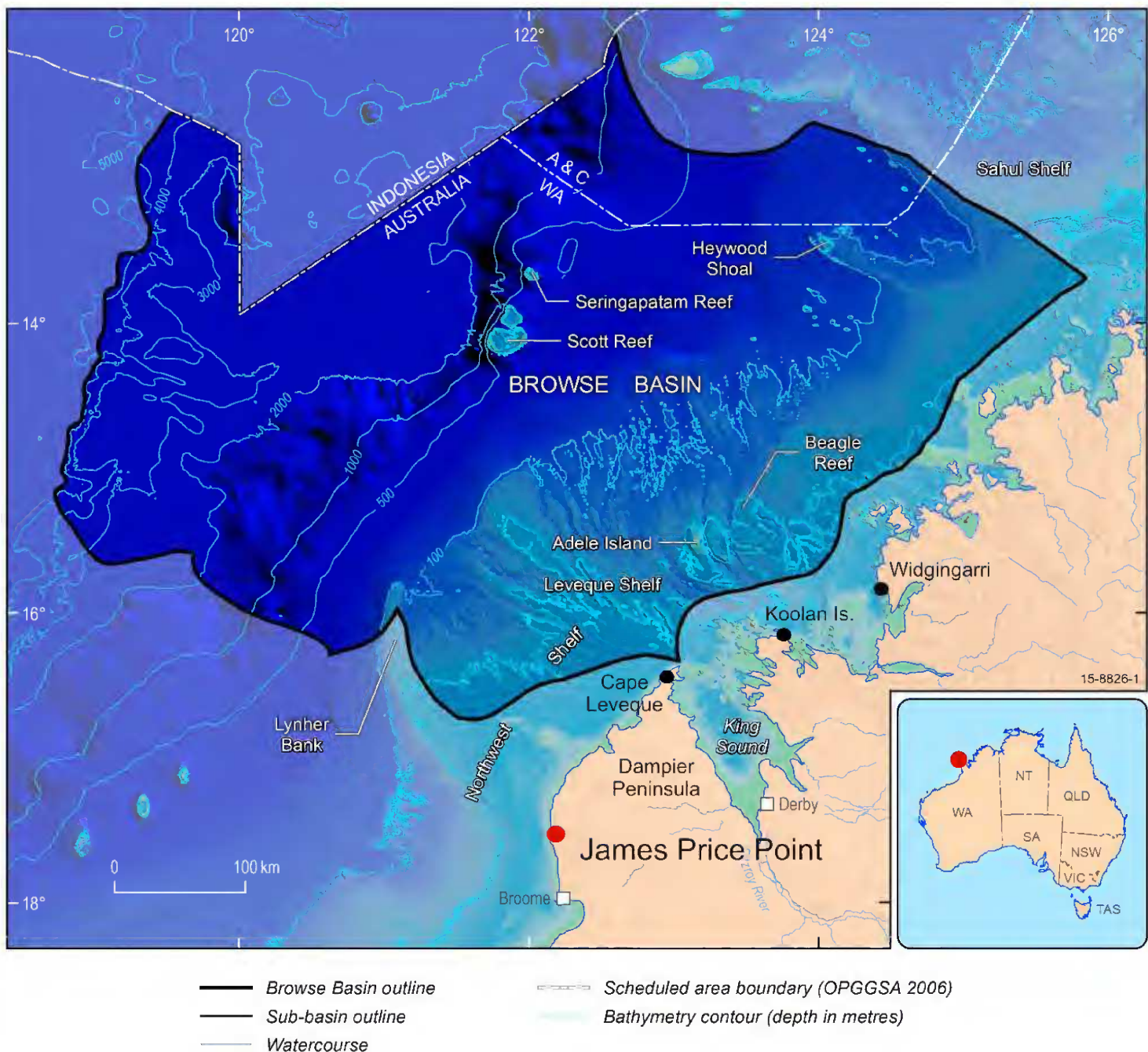


Figure 1. Map of Browse Basin and Leveque Shelf (© Commonwealth of Australia, Geoscience Australia 2015. This product is released under the Creative Commons Attribution 3.0 Australia Licence. <http://creativecommons.org/licenses/by/3.0/au/deed.en>).

Modern sedimentary processes on the continental shelf include transport by fast tidal currents and episodic cyclone-associated flows (Collins 2011). Coastal areas bordering the Leveque Shelf host strong, semi-diurnal tidal currents, and maximum tidal ranges over 10 m (Picard *et al.* 2014). The Kimberley region experiences frequent tropical lows, with an average of three per year (Lough 1998) producing strong onshore winds, enhanced wave energy and storm surges that influence the coastal geomorphology (Elliot & Elliot 2008). Despite this, undisturbed archaeological material both on and behind the cliff-top at Cape Leveque indicate long periods of stability (> 800 years) at least on some parts of this Kimberley coast (Barham & O'Connor 2007).

James Price Point (JPP)

The coastal geomorphology at James Price Point is characterised by a mixture of narrow beaches and rocky shores, with intertidal reef platforms of lithified coastal sediments, small spits and coastal dunes driven by the prevailing south-westerly winds, and adjacent Holocene terrestrial dunes (Eliot & Eliot 2008). To the south, these features give way to low-lying coastal dunes (Shoonta Hill sand; Semeniuk 2008), whilst to the north lie eroding cliffs of red sand (Mowanjum Sand; Semeniuk 1980), locally termed 'Pindan' (Lowe 2003). There is little fluvial sediment supply to James Price Point or the wider area, but wet-season rain drains across the coastal ridges and foredunes to the ocean through narrow ephemeral channels (Eureka 2010; Kenneally *et al.* 1996) or as subsurface seepage under the Mowanjum Sand (Mathews *et al.* 2011).

At JPP, the intertidal zone is generally rocky (predominantly coastal limestone) with patches of reef and wide (< 1 km) areas of intertidal sand flats, with weathered Broome Sandstone exposed in places at very low tides. The subtidal zone is generally shallow, with a complex configuration influenced by a series of exposed cemented relict shoreline features, scoured sub-tidal channels and fields of large, albeit low mobile, south-facing sand waves (Figures 2–4). The seabed sediments are generally sands of mixed terrigenous and biogenic composition, with carbonate content increasing offshore. Re-deposition occurs through regular transportation by strong, shore-parallel tidal currents. Measured in 34 m of water off JPP, spring tidal current speeds regularly attain 0.55 m/s near the bed and 0.8 m at the surface (RPS MetOcean 2012). Closer to shore, in 18 m of water, near-bed currents are typically 0.5 – 0.55 m/s at spring tides and able to mobilise the sandy sediments. During cyclones, current speed can be greatly enhanced. During Cyclone Laurence (December 2009), in 18 m of water, peak flows attained >1.15 m/s at the surface and 0.92 m/s near the bed, flowing to the south and south-south east along the shelf. Under these flow conditions, much of the seabed would have been in transport, redistributing much shell midden material and small stone artefacts, whilst less mobile stone tools might be buried below sand.

Seabed sedimentary features are key to understanding the geological setting and features, and the Holocene evolution of an area, and necessarily underpin an assessment of archaeological potential. Recent information on the North West Shelf (e.g. Hengesh *et*

al. 2011, 2012; Picard *et al.* 2014) contributes to regional knowledge. High-resolution survey data, including Light Detection and Ranging (LiDAR) data (Figure 2) indicates the presence of an array of submerged features (Figure 3). Together with available information on the sedimentary sequences and the coastal geology (DSD 2010a; 2010b; Eliot & Eliot 2008; GSWA 2009; Semeniuk 2008), this helps to delineate four main types of sedimentary deposits or features as a useful basis for assessing prehistoric marine archaeological potential. These are:

- Coastal Limestone – relict reef, probably dating from the last interglacial (Marine Isotope Stage 5, MIS 5). (Figure 2, and labelled as 'nearshore rock' in Figure 3).
- Palaeoshorelines – A series of coast-parallel features, including cemented carbonate dune and coastal deposits. The two main fossil shorelines (Figure 2) are here referred to as the -8 m and -15 m shorelines, relating roughly to mean sea level (MSL), to allow relatively easy comparison with the bathymetric datasets and images (MIS 1/2).
- Fossil Intertidal Flats – smooth and low-gradient areas landwards of the outer palaeoshoreline (Figure 2).
- Lagoon Infill – an infilled shore-parallel basin between the coastline and -15 m palaeoshoreline (labelled 'Marine Sands' in Figure 4) containing sediments up to 11 m thick (MIS 1/2).

EXISTING ARCHAEOLOGICAL INFORMATION

Regional archaeological context

Early Aboriginal occupation on the west Kimberley coast is documented at *Widgingarri 1* (from c. 50 ky BP) on the mainland (Veth & O'Connor 2013) and Koolan Shelter 2 in the Buccaneer Archipelago (from 27.3 ky BP, O'Connor 1999). The presence of shellfish remains and shell artefacts dated to between 28 – 26 ky BP at these sites indicates early exploitation and use of marine resources by Aboriginal people (O'Connor 1999; Veth & O'Connor 2013). Between 10,000 and 7,000 years ago, as coastlines and islands formed following sea level rise, previously abandoned rockshelter sites were re-occupied and new coastal sites occupied for the first time (O'Connor 1999). This rapid settlement of new coastlines and islands indicates that people had been living along the Pleistocene coast with well-developed maritime economies and following the rising sea (O'Connor 1999).

A mid- to late Holocene sequence of dated middens and cheniers from Cape Leveque to Roebuck Plains indicates continuing Aboriginal occupation of the coastal zone through 6,000 years of coastal progradation (O'Connor & Sullivan 1994; Smith 1987; 1997). South of Broome, shell middens yield dates between 3 and 1 ky BP (O'Connor and Veth 1993). The presence of flaked glass and historical material at a number of sites indicates that occupation of these places continued at least until the contact period and beyond (O'Connor & Veth 1993).

Archaeological sites on the Dampier Peninsula are concentrated on the resource-rich coastal margins,

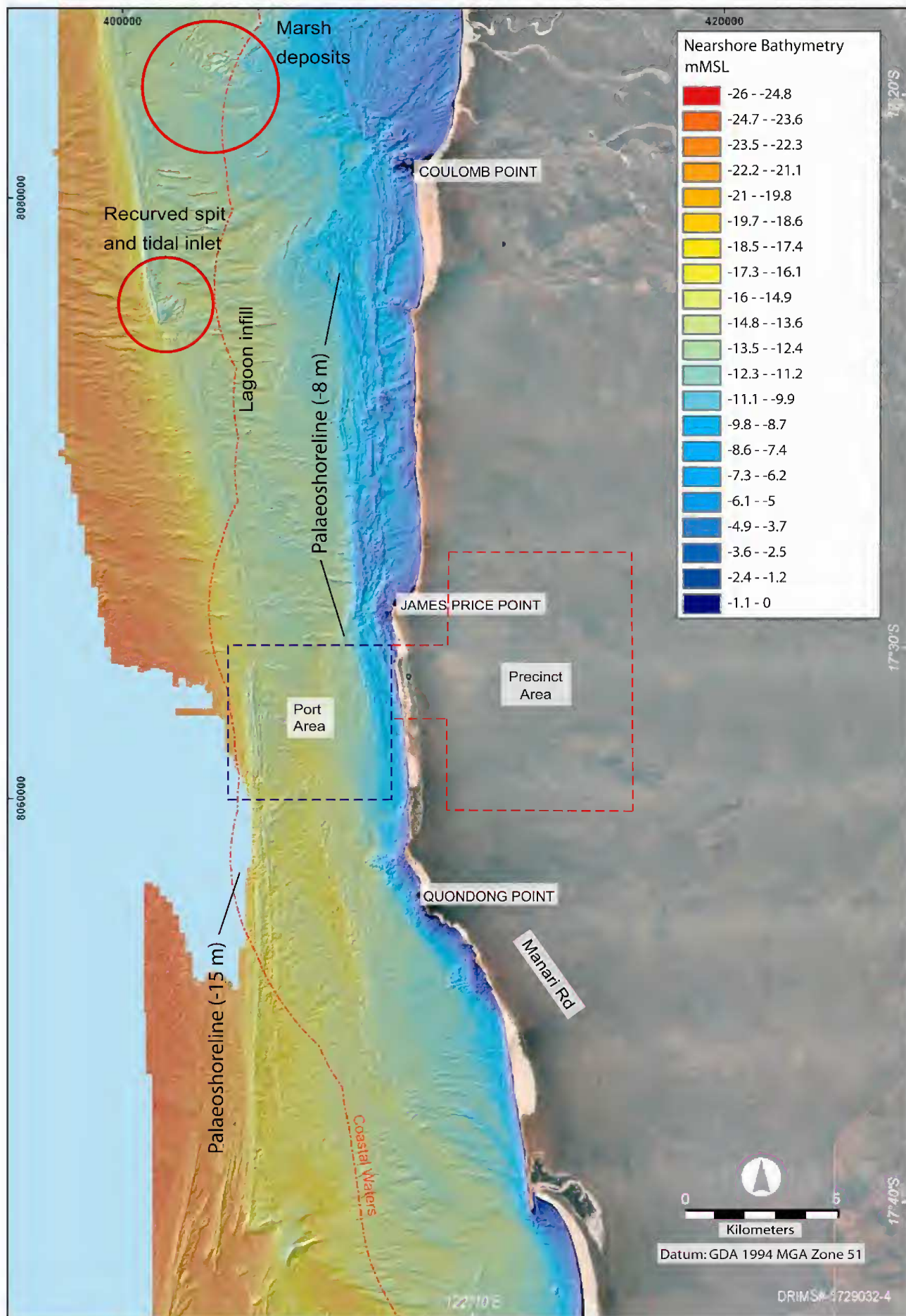


Figure 2. Surface topography and nearshore bathymetric image off JPP, showing detail of: left – the series of parallel N-S lineations of the -15 m shoreline; centre – the relatively flat smooth sea bed of the ‘lagoon’, and; central right – the NW-SSE shore-parallel lineations of the -8 m shoreline. The modern shoreline shows a rocky low intertidal zone, active upper beach, active and vegetated dunes, and blowouts. The Mowanjum Sand or ‘Pindan’ plain is located immediately to its landward (from DSD 2010a, Fig.1–8).

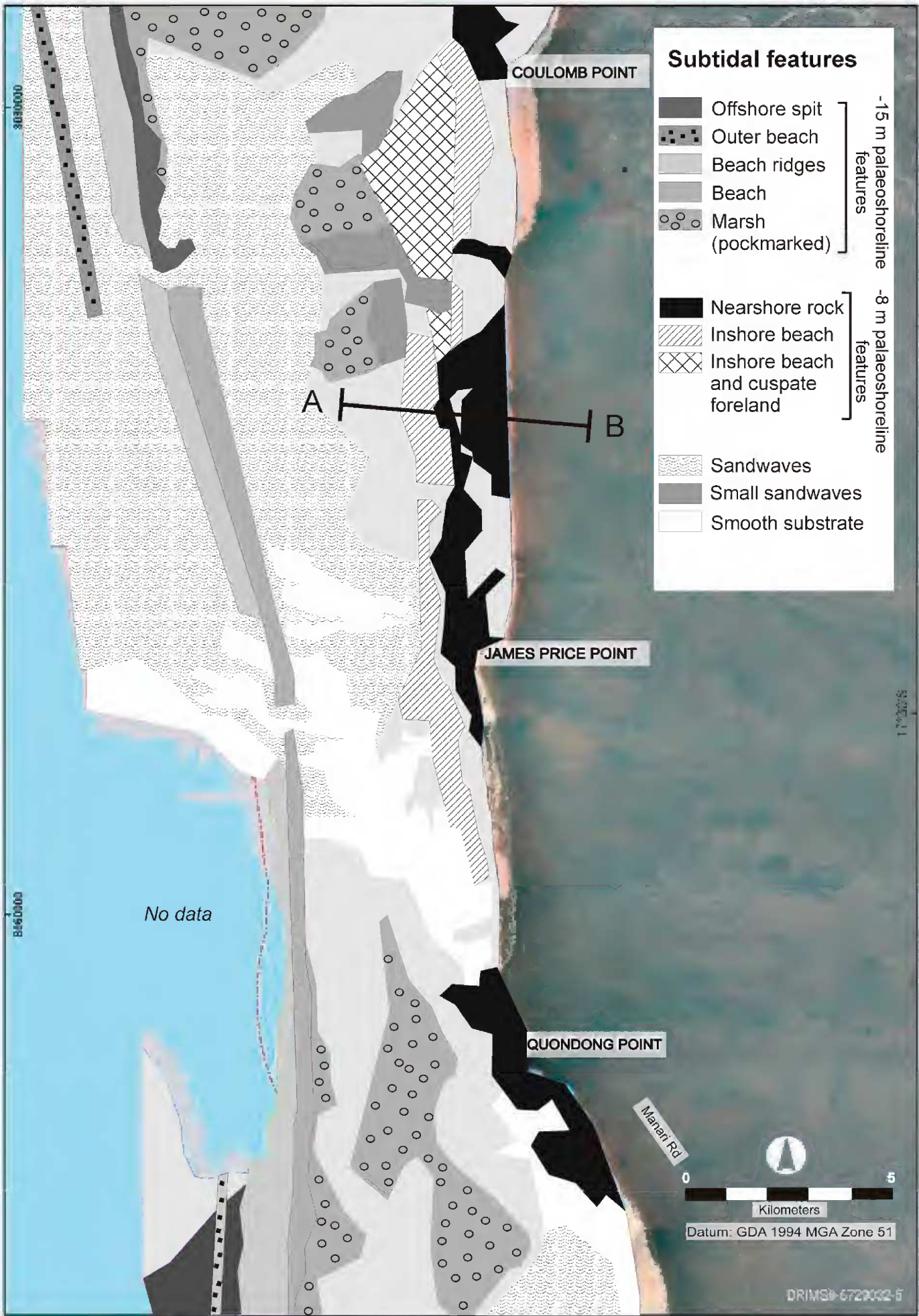


Figure 3. Main interpreted subtidal features in the James Price Point area, based on Figure 2 (sourced from DSD 2010a, Fig. 1–9). Line A–B marks location of section of Figure 4.

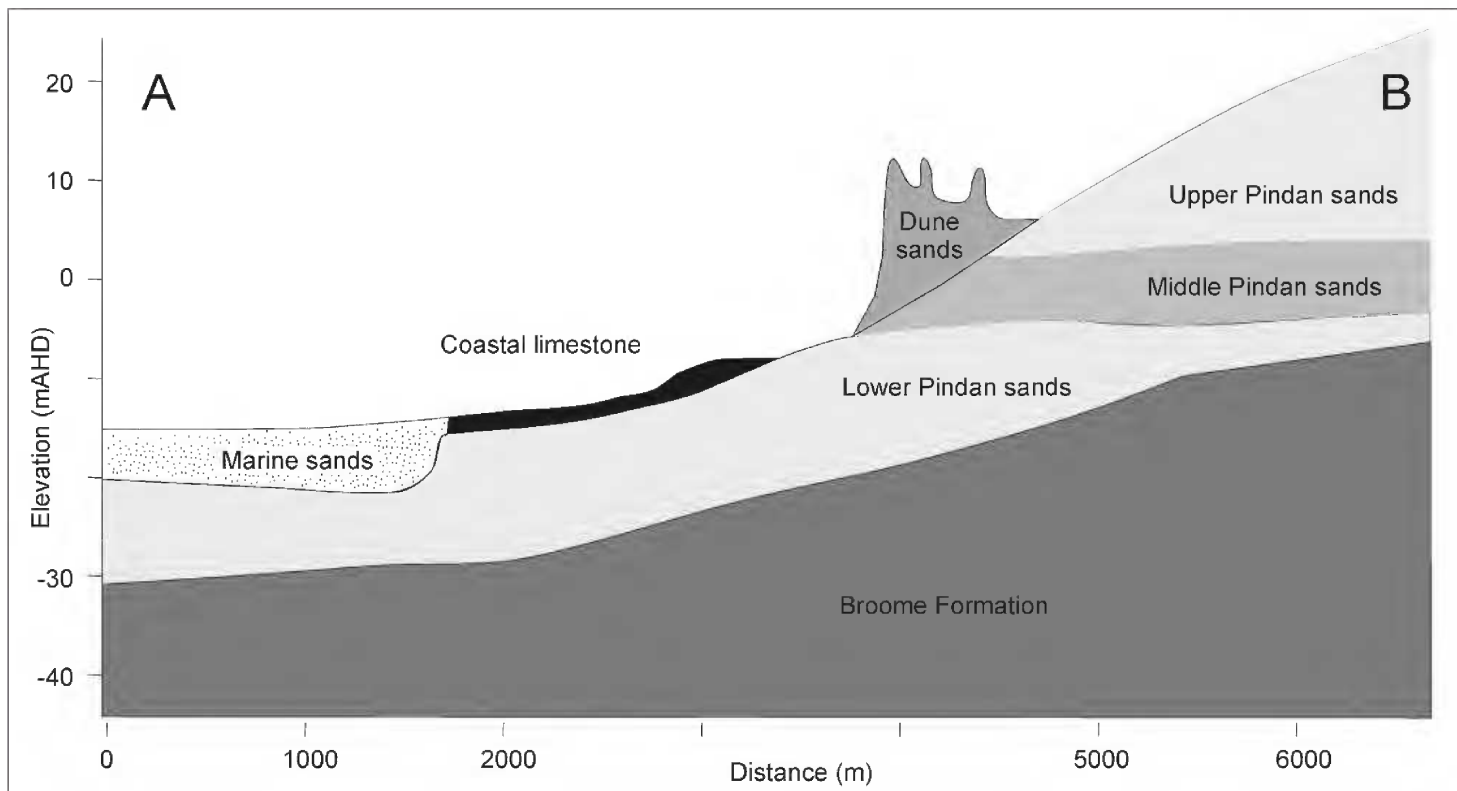


Figure 4. Simplified conceptual vertical cross-section across the coastline developed from the bathymetric survey, four geotechnical boreholes (three to ~20–22 m below seabed, one to 7 m) and some seismic reflection survey results (not to scale; DSD 2010, Fig. 1–6). Coastal limestone is also inferred to occur in places within the lagoon infill but is not illustrated here. Boreholes indicated the Pindan comprised reworked fine and sometimes silty red brown sand, and the basal Broome Formation was represented by weathered very weak sandstone.

with major campsites located within 2 km of the ocean (Smith 1987:43). The vast majority of recorded coastal sites are shell middens, which vary greatly in location, size, density and the types of shell species exploited. The middens tend to occur on both Holocene dunes and low cliffs of ferruginous red sands and soils (Mowanjam Sands), in deflated sedimentary environments and in stratified deposits.

Invariably they include shellfish remains such as mangrove/mudflat species *Terebralia* sp. and *Anadara* sp., and/or rocky intertidal species, such as snail (*Nerita* sp., *Turbo* sp.), murex (*Hexaplex* sp.), *Trochus* sp, clams (*Barbatia* sp.), oyster (*Saccostrea* sp.) and baler shell (*Melo amphora*). The remains of other marine species such as fish, turtle and dugong also occur (Smith 1997; O'Connor & Veth 1993).

A number of well-known silcrete quarries occurs along the west coast of Dampier Peninsula, and many of the shell middens in the south west Kimberley contain stone artefacts (Akerman 1975; Akerman & Bindon 1984). Specialised tools found elsewhere in the Kimberley, such as tula and burren adzes used for wood-working, are largely absent on the Dampier Peninsula (Akerman & Bindon 1984). These are replaced by specialised tools made of shell, including shell adzes, spoons and anvils used to process shellfish, as well as a variety of exotic lithic materials sourced off the peninsula. Further evidence of a flexible coastal-economy is the presence of 39 late-Holocene stonewall fish traps identified along the Dampier coastline (Smith 1997). In the vicinity of Bidyadanga (La Grange) and on the northern Dampier Peninsula, these structures extend for hundreds of

metres, and are amongst the largest anthropogenic intertidal structures in Australasia. More fish traps and stone-wall structures may be found by further survey of rocky headlands and intertidal rocky outcrops at low tide (Smith 1997: 20). Clearly, similar structures might exist below the present low tide mark.

Local coastal archaeology

In pre-European Australia, Aboriginal people made extensive use of the James Price Point area, including as a locally important resource area and water source (Smith 1997:46). The area forms a part of an extensive song-cycle, which stretches along the coast from Roebuck Bay to Coulomb Point, 10 km north of James Price Point (Bradshaw & Fry 1989; Roe & Muecke 1983). Notably, the traditions of the local Jabirr Jabirr people – whose lands encompass James Price Point – extend to the adjacent waters and include offshore features that are visible several kilometres away (Leo 2012). The 2015 Department of Aboriginal Affairs (DAA) Register of Aboriginal Sites indicated a number of multi-component archaeological and ethnographic sites, within a 20 km (N-S) × 10 km (E-W) area surrounding the development area. These include mythological and ceremonial sites (12), midden/artefact scatters (21), two quarries, two fish-trap sites and a water source. The two fish traps, *Kardilakan-Jajal* (DAA Site ID 13504) and *Yaljarriny-Gardarlargun* (DAA Site ID 13076, previously *Waldamany*) (Figure 5) constitute the only known prehistoric cultural sites in the intertidal parts of the development area. Three of the Aboriginal shell midden sites, *Yaljarriny-Gardarlargun* (DAA Site



Figure 5. Photo of Yaljarriny-Gardarlargin fish trap exposed at low tide (scale bar is 1 m).

Table 1. List of registered DIA sites (at 2012) and new unregistered sites (Eureka, 2012) at James Price Point. All are terrestrial or coastal. As of 2015, only the Waldaman site remains a registered site.

DIA ID no.	Site name	Site attributes
12864	Inballal Karnbor	Ceremonial, Mythological
12900	Ngarrimarran Junu Quarry	Quarry, Artefacts /scatter
12902	Kundandu	Mythological, Artefacts/scatter, Midden/scatter
12903	Murrjal	Mythological, Artefacts/scatter, Midden/scatter
13076	Waldaman (<i>Yaljarriny-Gardarlargin</i>)	Skeletal material/Burial, Fish Trap, Artefacts/ scatter, Midden/scatter
13504	Kardilakan - Jajal	Ceremonial, Mythological, Fish Trap, Artefacts /scatter, Midden/scatter
Not registered	Shell Scatter 1	Midden/scatter
Not registered	Silcrete Quarry Site	Low silcrete outcrop with artefacts
Not registered	Baler Artefact Site (salvaged May 2011)	Broken baler shell artefact and scatter

ID 13076), *Kundandu* (*'Gardarlargin-South'*, DAA Site ID 12902) and *Inballal Karnbor* (DAA Site ID 12864) are located within the coastal dunes of the development area, and other sites within 2 – 3 km of the development area include *Ngarrimarran Junu Quarry* (*'Yaljarriny-Guumbar'*, DAA Site ID 12900) and *Murrjal* (DAA Site ID 12903) (Table 1).

Midden sites range from small, discrete concentrations of stone artefacts and shell material (dinner-time camps), to large multi-component sites extending for kilometres along the coast. Shell middens typically contain a wide range of shellfish species that are found in the adjacent rocky/intertidal environs. Most sites are located in blowouts in the Holocene dunes (Table 3) where accumulations of stone artefacts and shell material, probably representing repeated human visits, are exposed by (episodic) deflation of stratified deposits. The middens' stone artefacts are mostly manufactured from locally available silcrete and are dominated by unmodified flakes, grinding material. Hammerstones, anvils and hearth features are common. Quarry sites are more common on the cliffs that cut into the Mowanjum Sand, with outcrops of high-quality silcrete suitable for

tool stone. Lenses of shell and artefacts are also visible in cliff sections but dense grasses and scrub growing on the cliff tops typically obscure surface archaeological material. Surveys also identified an additional shell midden site, a silcrete quarry and a baler-shell artefact

Table 2. Dated AMS measurements for shell material from Waldaman Site (DIA Site ID 13076). Dates, sourced from Eureka 2012, are calibrated at 2 standard deviations (95%) using the Marine Calibration with a regional offset (δR) of 54 ± 30 based on Squire *et al.* (2013).

Material dated	Lab code	Depth (cm)	Radio-carbon age	Calibrated age (BP)
<i>Muricadae</i> sp.	Wk-31557	4	1385 ± 25 BP	772 - 958
<i>Muricadae</i> sp.	Wk-31558	5	1861 ± 25 BP	1271 - 1463
<i>Saccostrea</i> sp.	Wk-31559	0	1396 ± 26 BP	778 - 971
<i>Saccostrea</i> sp.	Wk-31560	18	1772 ± 27 BP	1180 - 1349
<i>Saccostrea</i> sp.	Wk-31561	100	1876 ± 25 BP	1281 - 1477
<i>Haliotis</i> sp.	Wk-31562	40	1757 ± 28 BP	1173 - 1334
<i>Saccostrea</i> sp.	Wk-31563	100	2486 ± 25 BP	1941 - 2202
<i>Saccostrea</i> sp.	Wk-31564	300	4537 ± 25 BP	4546 - 4803



Figure 6. Location of Waldaman excavation at James Price Point. The series of shell lenses in the cliff face date from ~ 5 ky BP, ~ 2 ky BP and ~ 1 ky BP respectively up the profile.

site, located 1.6 km, 6 km and 9.6 km respectively inland on the sand sheets (Eureka 2012).

A sample of *Turbo* sp. collected in 1988 from an *in situ* lens of shell at 50–100 cm below the surface of Mowanjum Sands immediately north of James Price Point yielded a radiocarbon age of 989 – 1282 cal. BP (SUA 2826; Smith 1987). A 1 x 1 m excavation, undertaken in 2012 for the Browse project and within the *Yaljarriny-Gardarlagun* site, focused on the cliff edge than 200 m south of this first dated shell lens (Figure 6). Although the basal occupation layer was not reached, an oyster shell (*Saccostrea* sp.) from ~3 m below the surface yielded a radiocarbon age range of 4.8 – 4.5 cal. ky BP (Wk-31564) (Table 2) and indicates use of the site for around the last 5,000 years or more (Eureka 2012). Radiocarbon dating of other shell material, presumably representing food remains, including oyster (*Saccostrea* sp.), abalone (*Haliotis* spp.) and murex (*Muricidae* sp.) from shallower deposits ranged in age from 1.0 – 0.8 ky BP (Wk-31557) to 2.3 – 1.9 ky BP (Wk-31563). These dates correspond well with other midden scatters on the south west Kimberley coast (O'Connor & Veth 1993; O'Connor & Sullivan 1994; Smith 1987), and indicate the exploitation of the coastal zone around James Price Point from at least the middle to late Holocene.

DEVELOPMENT OF AN IMAP FOR JAMES PRICE POINT

The following describes the prehistoric marine archaeological potential of the James Price Point area (see also Figure 7; Table 3). In the absence of an absolute chronology for the different landform units in the development area, the assessment of relative age for any associated potential archaeology is based on available geological and stratigraphic information (DSD 2010a, b; Eliot & Eliot 2008; Lessa & Masselink 2006).

Coastal Limestone (archaeological potential = low-medium)

Here we use the term coastal limestone to describe hard cemented features not obviously related to a drowned bathymetric palaeoshoreline feature. Such coastal limestones are sandy coastal sediments of mixed composition but dominated by carbonate grains, which have been cemented by groundwater carbonates, forming beachrock in the case of the intertidal zone. Generally around 1 m thick, the coastal limestone's primary location is near the modern shoreline (labelled the 'nearshore rock' of Figure 3), but also occurs in places

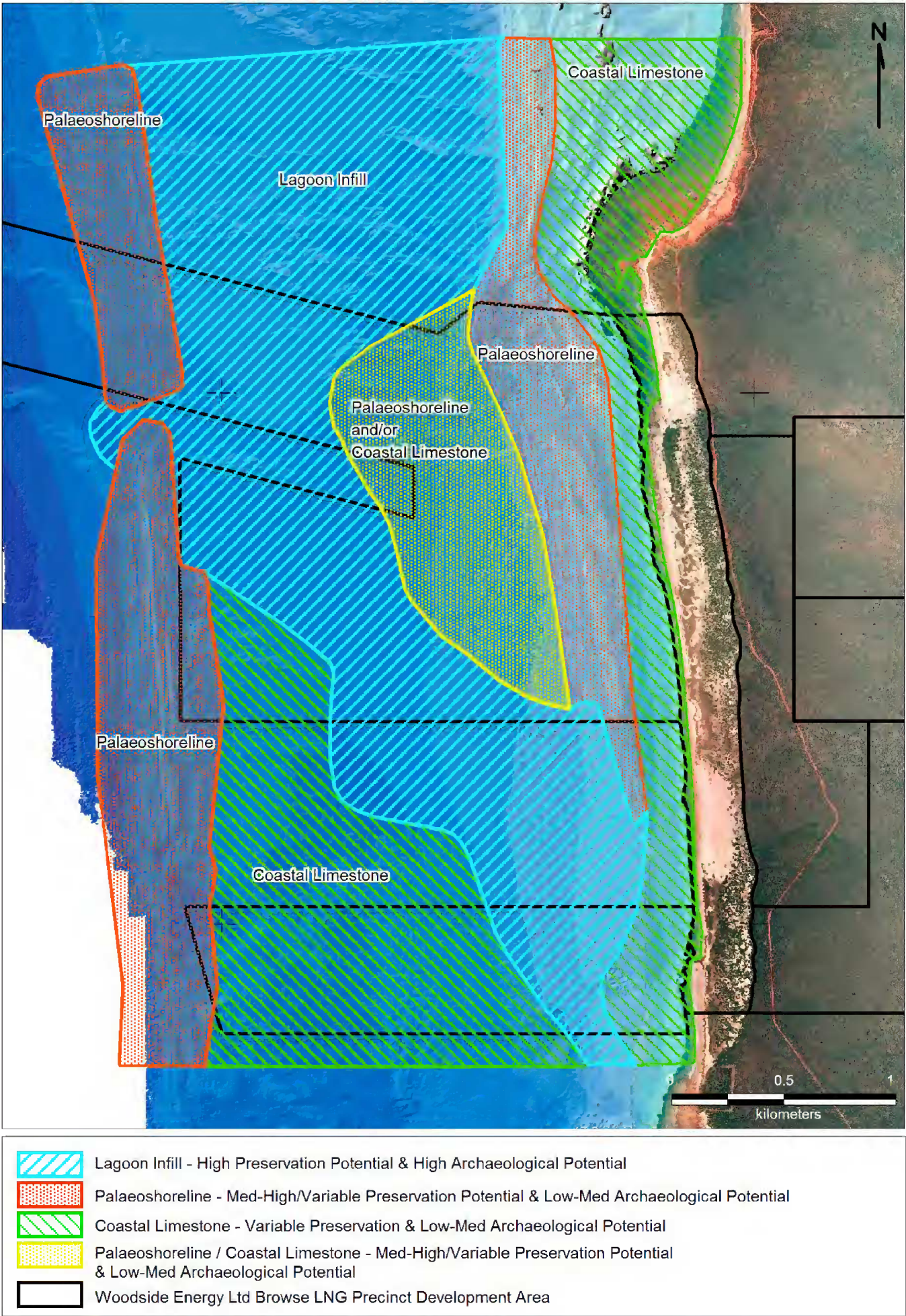


Figure 7. IMAP for shallow marine area offshore from James Price Point, showing areas of relatively low (coastal limestone), medium (palaeoshoreline) and high (lagoon) archaeological potential. Refer text for detail.

Table 3. Inferred archaeological association within terrestrial, coastal and marine depositional environments at James Price Point (JPP).

Landform or sedimentary feature	Inferred age	Sediments	Archaeological association	Known sites (DAA Site ID) and/or isolated finds	Preservation potential	Archaeological potential	Observed local archaeology and/or related archaeological evidence
Mowanjum Sand ('Pindan') sand sheets	<i>Quaternary</i> Pleistocene	Ferruginous quartz sand with pisoliths, minor clay	Primary	Both (Geotech Scatter not registered)	High	Medium	Discrete stone artefacts and stone and shell scatters recorded in Pindan sand sheets, subsurface finds identified through test-pitting
Creeks	<i>Quaternary</i> Pleistocene	Mostly ferruginous quartz sand	Secondary	Isolated finds	Low	Medium	Discrete artefacts recorded in ephemeral creeks near Quondong Point (Fig. 1)
Mowanjum Sand ('Pindan') cliffs	<i>Quaternary</i> Pleistocene	Ferruginous quartz sand, minor clay	Primary	Both (e.g. ID12427, 12900, 13076)	Low-medium	High	Lenses of shell and artefacts observed in Pindan cliffs at and to the north of JPP.
Aeolian dune system	<i>Quaternary</i> Holocene	Carbonate and siliceous shelly sand	Primary, Secondary	Both (e.g. ID13076, 12901, 12902, 12903, 13504)	Medium	High	Numerous middens recorded in deflated and stratified deposits in dunes along many parts of the west Kimberley coast.
Sandy beach	<i>Quaternary</i> Holocene	Carbonate and siliceous shelly sand	Secondary	Isolated finds	Low	Low	Isolated artefacts (from cliffs and dune middens) observed on the beach north and south of JPP.
Intertidal flats	<i>Lower Cretaceous</i> Broome Sandstone	Cemented sandstone	Primary and Secondary	Sites (e.g. ID 13076, 13504)	Medium	Medium	One registered fish trap at James Price Point, other known and registered fish traps along West Kimberley coast.
Coastal limestone	Pleistocene (Last Interglacial)	Cemented carbonate	Secondary	Isolated finds in beach rock north of JPP	Variable	Low-medium	Cemented artefacts in beach rock (e.g. Cawthra &Uken 2012).
Palaeoshoreline	Early Holocene	Carbonate and siliceous shelly sand	Secondary	Both	Medium-high	Low-medium	Cemented artefacts in fossil dunes (e.g. Dortch &Hesp 1994; Cann <i>et al</i> 1991.)
Fossil intertidal flats	Early Holocene	Rock platform	Secondary	Both	Medium-high	High	Known foraging area (e.g. O'Connor & Veth 1993, Smith 1997).
Lagoon infill	Early Holocene	Carbonate and siliceous shelly sand	Primary and Secondary	Isolated finds	High	High	Natural 'sink' for eroded artefacts

as part of the drowned palaeoshorelines and within the lagoon-infill sequence, the latter inferred from areas of relatively strong seismic reflections on the sub-bottom geophysical profiles. Fluctuations in the position of the coastline, and associated changes in the water table, can produce an asynchronous beachrock deposit into which archaeological material might become cemented (e.g. Cawthra & Uken 2012; Dortch & Hesp 1994) sometimes very rapidly (e.g. Friedman 1998). The overall archaeological preservation potential depends very much on cementation and post-drowning marine erosion, and so such beachrock deposits are likely to contain discrete low-density or isolated artefacts.

Palaeoshorelines (archaeological potential = low-medium)

With changes in relative sea level, the location of associated shorelines also changes. Over time, climatic and sedimentological conditions, such as sub-aerial exposure, may allow preservation of palaeoshorelines, including possible combinations of (cemented) beach deposits, beach ridges and coastal dunes. Drowned palaeoshorelines off James Price Point form at least two series of north - south trending linear features with relief of up to 5 m or more above the surrounding seabed, at elevations of - 15 m and - 8 m respectively (Figure 2). Based on relative sea level curves (e.g. Lambeck *et al.* 2014) and ignoring the relatively minor changes in tidal range over the late transgression (see Ward *et al.* 2013), these fossil shorelines may date to ~ 9 ky BP and ~ 6 ky BP respectively. Thus, regardless of any associated archaeology, this series of palaeoshorelines, with excellent seabed expression, is itself of high geological, palaeogeomorphological and sea-level significance.

In parts, the linear palaeoshorelines at JPP and their re-curved ends closely resemble modern barriers, tidal

inlets and marshy back-barrier areas (Figure 8). Close to the modern shoreline, particularly north of James Price Point and near Coulomb Point, complex lineations occur which suggest a cusped shoreline once extended into a semi-protected lagoon or occurred behind a barrier island. Both morphologies are typical of barrier spits that occur where there is an abundant supply of sediment and high rates of longshore transport (Davis & Fitzgerald 2009). As evidenced by archaeological sites on the contemporary coast, these shorelines might have been places dinner-time camps occurred, with consumption of food collected from the adjacent intertidal and lagoon environments. On the landward side of the coastal dune system, preservation of any midden, stone artefact or other archaeological deposits would depend on burial and/or cementation by aeolian processes (e.g. Dortch & Hesp 1994), and on the seaward side by beach accretion and cementation (e.g. Cann *et al.* 1991). The long-term preservation potential of such shoreline deposits (taken as a whole) is medium-high, with a low-medium archaeological potential, mostly of material in a secondary depositional context, i.e. redeposited.

Fossil intertidal flats (archaeological potential = high)

Just north of Coulomb Point and immediately landward of the -15 m palaeoshoreline occur low-gradient relatively smooth platforms (Figure 2). These platforms probably represent a range of intertidal and back-barrier deposits, including reef flats, infilled tidal creeks, salt-marshes and/or salt-flats. Such resource-rich environments were once (e.g. O'Connor & Veth 1993; Smith 1997) and continue to be exploited by humans for a range of traditional marine activities (Bradley 2010). This is an area where fish-trap or stone weirs and midden deposits may be found, as they are now in the contemporary intertidal and adjacent coast around James Price Point. Such back-barrier intertidal deposits typically represent relatively

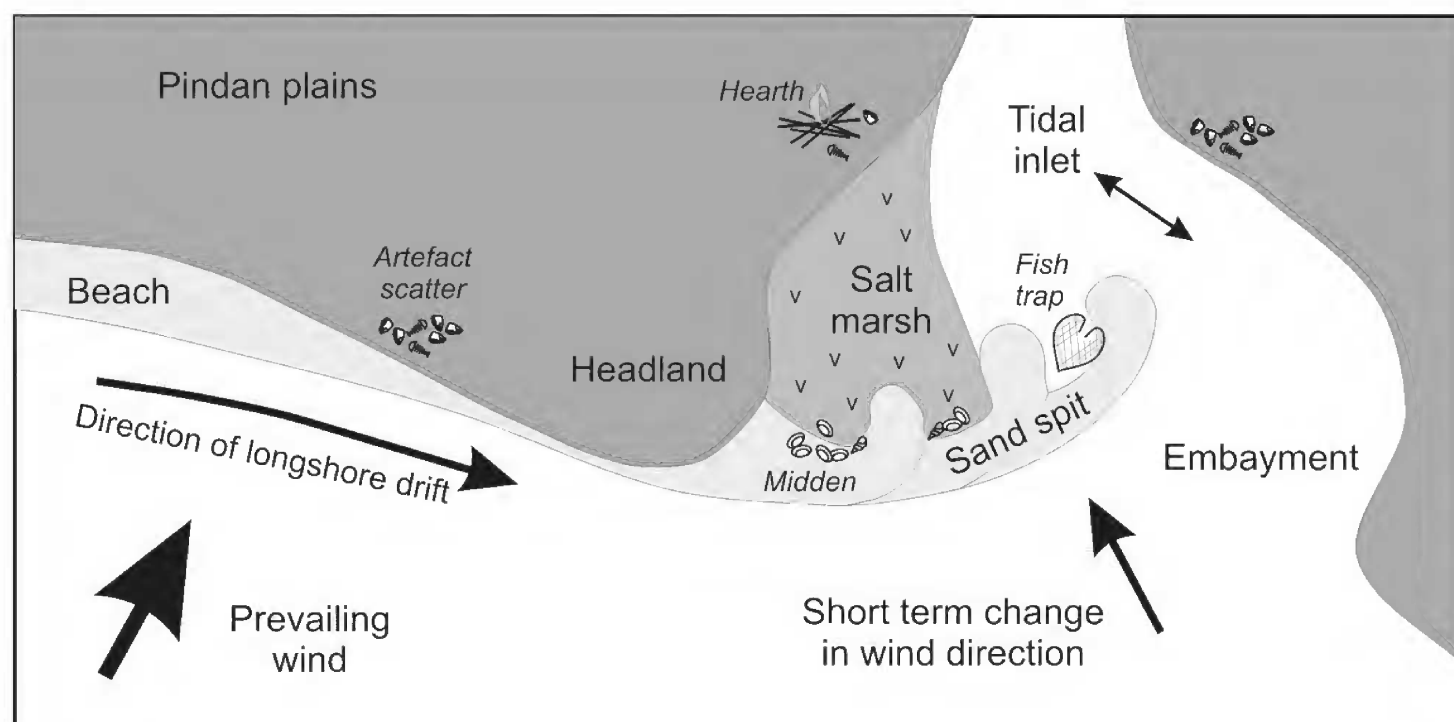


Figure 8. Schematic diagram showing the typical development of a recurved spit, behind which exists a salt marsh, which would have provided a focal area for procurement of intertidal and marine resources by past occupants.

low-energy environments and have probably been largely undisturbed since their accumulation. Overall, these deposits have both high archaeological potential and medium-high preservation potential.

Lagoon infill (archaeological potential = high)

Between the -15 m and -8 m palaeoshorelines is a broad area of bathymetrically relatively smooth sea bed, with surface sediments of clean biogenic sands, rich in foraminifers and, in places, formed into large sand waves (Figure 2). Below much of this area lies between 0.25 m and >7 m of loose grey to light grey sands, quite uniform in nature throughout the area, and probably of late Holocene age (Figure 4). These sands represent the infill of a fossil lagoon, which is a key unit in the inner-shelf sedimentary succession because it may have changed successively through time during the late parts of the transgression (the last 7,000 years or so) from a brackish or estuarine setting, to a fully marine setting, which changes will have offered a wide range of exploitable resources to past occupants.

There have been relatively few processes through time which will have exported material in bulk from this basin, so these sediments have a high preservation potential for secondary artefacts transported by past and present runoff into the basin from the Pindan sand plain into the zone to landward of the -15 m paleoshoreline feature. Even today it is possible to see artefacts and shell being eroded from the red dunes and transported to the adjacent coast (Figure 9; see also Smith 1997:46). Undisturbed archaeological material may also exist in

these complex lagoonal deposits, particularly if there are any discrete patches of organic-rich sediments in the sequence, because these would represent low energy deposits, are least likely to be disturbed and may preserve organic artefacts relatively well.

DISCUSSION

Preservation and significance of relict landscapes

Awareness of submerged pre-European cultural potential in Australia is slowly increasing (Staniforth 2007; Ward *et al.* 2013; 2014b; 2015; Nutley 2014; Veth *et al.* 2014; see also Gusick & Faught 2011), and is being aided by high-quality marine data that makes drowned preserved relict landscape features very apparent. Over the past decade, palaeoshorelines have been mapped and identified across a limited range of shelf settings, including the outer Gulf of Mexico (Allee *et al.* 2012), Bermuda (Iliffe *et al.* 2011) and the Mediterranean (Passaro *et al.* 2011). The interpretations made using the high-resolution bathymetry at James Price Point clearly highlight the presence of relict coastal landscapes here, in common with their broader occurrence on the northwestern continental shelf of Australia (see also Picard *et al.* 2014). At a broad scale, a complex network of valleys, banks, and terraces indicates a drowned terrestrial and coastal landscape that allows for analogies to be made with known archaeological sites on the contemporary coast. Morphologically, the drowned valley systems strongly resemble the modern estuarine complexes present along



Figure 9. Photo showing erosion and runoff of material from the Mowanjum Sands into the intertidal zone at James Price Point. Artefacts, possibly derived from within the Mowanjum Sands, were observed on these eroding surfaces.

the modern Kimberley coastline and, further, some of the submarine bathymetric ridges are morphologically similar to the beach-ridge coastal plains of northeastern Australia (Semeniuk 2011; Short 2011). The stable tectonic setting means that these submerged features remain at depths that closely match the global sea-level record (Brooke *et al.* 2010; 2014; Nichol & Brooke 2011). Therefore, the area not only provides a unique record of past sea-level change but also potentially of early human coastal resource use in this northern corridor of Australia (see Veth *et al.* 2014; Ward *et al.* 2013; 2014b; 2015).

The wide range of submerged sedimentary deposits in the James Price Point region, each with relatively unambiguous interpretation, represents a suite of environments with the clear potential to contain archaeological sites and artefacts, including those pertaining to early coastal occupation. Specifically, the available submarine geological and bathymetric data clearly indicate that a series of cemented palaeoshoreline deposits are preserved on the seabed, potentially dating (based on sea-level curves) between 9 ky and 6 ky BP (Figure 2), which may also contain lithic or midden deposits. Behind these are intertidal deposits and an infilled lagoon, which are likely to have provided a rich resource for past occupants when this area was exposed and may now preserve archaeological material in either primary or secondary depositional contexts.

The clear bathymetric expression of the fossil dunes is partly a result of the low Holocene rates of sediment accumulation on the shelf, both regionally (Collins 2011) and more locally, which has prevented their burial beneath younger sediments. However, given the cyclone-prone nature of the region, which can readily mobilise sediments across northern Australia's continental shelves (Carter *et al.* 2009; Larcombe & Carter 2004; Larcombe *et al.* 2014), their cemented nature is the key factor in boosting archaeological potential because it will have greatly increased the preservation and archaeological potential not only of the palaeoshoreline deposits themselves but also of those deposits (both primary and secondary) to landward. Further, the clarity of resolution of these submerged past environments, and their likely archaeological potential means that, theoretically at least, there might be the potential to compare artefacts from equivalent deposits of different ages that might indicate early maritime adaptations.

The geoheritage significance of the Kimberley coast is well-documented (Bronx and Semeniuk 2011), and the fossil shorelines of James Price Point are by no means unique – they merely form part of an extensive series of palaeoshorelines of regional scale (Fairbridge 1964 in Wyrwoll 1979:134; James *et al.* 2004; Semeniuk & Searle 1987). However, they are particularly well preserved along the coastline around James Price Point, probably in part due to the lack of supply and accumulation of terrigenous sediments here throughout the Holocene. This palaeogeography is sufficient to warrant the area to be considered of significant geoheritage value (Bruno *et al.* 2014) and worthy of dedicated marine archaeological investigation. High-resolution LIDAR and 3D geophysical survey imagery is continuing to reveal drowned fossil dune ridges and palaeoshoreline sequences along much of the WA continental shelf, including near Perth (Brooke *et al.* 2010; Semeniuk &

Searle 1987; Stul *et al.* 2015), at Ningaloo Reef (Collins *et al.* 2003; Nichol *et al.* 2012; WAMSI 2008) and off Port Hedland (BHP Billiton 2008). The clear implication is that there is the potential for pre-European landscapes and marine archaeological sites to be preserved over many hundreds and possibly thousands of kilometres of the WA continental shelf. Some of these may have an archaeological (and palaeoenvironmental) potential equal or better than JPP because they exist in a relatively protected setting (e.g. within an archipelago) or have a past or present riverine and floodplain around which past occupants may have focused (e.g. Fortescue River) and will have a similarly rich and early (> 10,000 yr old) archaeological context.

Worldwide expansion of marine developments (e.g. ports, harbours, windfarms) introduces a key challenge to research our understanding of the potential impacts of marine development activities on known and potential prehistoric cultural resources (Evans *et al.* 2009; Flemming 2004; Kamoot 2014; Staniforth 2007; Ward *et al.* 2014a). This requires an effective exploration of the key regional issues, including research to support geoarchaeological assessments of marine sustainability and marine cultural heritage management at the State, Territory and National scales, recognising the differences in the cultural (McNiven 2003), physical (see Ward *et al.* 2015) and legislative (e.g. Butterley 2012; 2013) factors relevant to different parts of the Australian coastline. Our work indicates that there is much to be gained in terms of 'pure' and applied research by examining the preserved drowned shorelines, and that effort might focus on lagoon infill and fossil intertidal flats.

CONCLUSIONS

At James Price Point, northern Western Australia, middens, intertidal fish-traps and archaeological excavation at James Price Point provide evidence of coastal exploitation from at least 5 ky BP. In the adjacent marine environment are well-preserved drowned shoreline sediments, which form at least two series of north - south trending linear features with relief of up to 5 m of more above the surrounding seabed, at elevations of - 15 m and - 8 m respectively, which may date to ~ 9 ky BP and ~ 6 ky BP respectively. Along with lagoon and fossil intertidal landscapes, the well-preserved drowned palaeoshoreline are of significant geoheritage value and also have very high archaeological potential. The excellent preservation of relict shoreline features along this and other parts of the northwest Australian continental shelf and coastline highlights the need for greater formal consideration of the submerged prehistoric cultural heritage in marine and coastal developments that is current lacking in the marine statutory framework.

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